

NASW-4066

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MARTIAN CLOUDS DATA WORKSHOP



MECA

(NASA-CR-182431) MARTIAN CLOUDS DATA
WORKSHOP (Lunar and Planetary Inst.) 30 p
CSCL 03B

N88-20238

Unclas
G3/91 0122830

 **LPI Technical Report Number 87-03**
LUNAR AND PLANETARY INSTITUTE 3303 NASA ROAD 1 HOUSTON, TEXAS 77058-4399

MARTIAN CLOUDS DATA WORKSHOP

Edited by

Steven Lee

Sponsored by

Lunar and Planetary Institute

Hosted by

Laboratory for Atmospheric and Space Physics

University of Colorado

Boulder, CO

June 3-5, 1987

Lunar and Planetary Institute 3303 NASA Road 1 Houston, Texas 77058-4399

LPI Technical Report 87-03

Compiled in 1987 by the
LUNAR AND PLANETARY INSTITUTE

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This report may be cited as:

S. Lee, ed. (1987) *Martian Clouds Data Workshop*. LPI Tech. Rpt. 87-03. Lunar and Planetary Institute, Houston. 27 pp.

Papers in this report may be cited as:

Author A. A. (1987) Title of paper. In *Martian Clouds Data Workshop* (S. Lee, ed.), pp. xx-yy. LPI Tech Rpt. 87-03. Lunar and Planetary Institute, Houston.

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Martian Clouds Data Workshop

Background and Purpose

The "Martian Clouds Data Workshop" was held at the University of Colorado's Laboratory for Atmospheric and Space Physics (LASP) on June 3-5, 1987. This workshop was the first research use of the prototype Planetary Data System (PDS) Atmospheres Node database. Sponsorship was provided by the PDS in the form of support for database development, and by NASA's MECA (Mars, Evolution of Climate and Atmosphere) program in the form of travel funds administered through the Lunar and Planetary Institute. Fifteen people participated over the course of the three-day workshop.

Prior to the workshop, several datasets were obtained and entered into the Node's database. These were deemed, by a poll of prospective workshop participants, to be useful for investigating topics related to martian clouds and the microphysics of the martian atmosphere. Many of the attendees had previously utilized one (or a few) of the available clouds-related datasets, or had contributed one of these datasets, but had not had the opportunity to intercompare several datasets. The available datasets included:

- (1) Viking Orbiter and Mariner 9 image-based cloud catalog;
- (2) Viking Orbiter Infrared Thermal Mapper (IRTM) cloud catalog;
- (3) Viking Orbiter Mars Atmospheric Water Detector (MAWD) dataset;
- (4) Viking Lander Meteorology Experiment datasets:
 - (a) point-by-point pressure (full time resolution);
 - (b) daily average pressure (one bin per day);
 - (c) binned pressure, temperature, and wind speed (25 bins per day);
- (5) Viking Orbiter IRTM albedo map;
- (6) Viking Orbiter IRTM thermal inertia map.

The purposes of the workshop were twofold:

Provide the data and analysis capabilities to investigate topics related to martian clouds in fashions that were previously either very difficult or impossible to achieve: The Atmospheres Node database readily allows correlative studies using multiple datasets; this capability includes, for example, searching the database for all information occurring at the same time and/or location, retrieving all data meeting the selected temporal and/or spatial constraints, and subsequently applying relevant data analysis techniques and the combined "group expertise" to aid with interpretation of the selected data.

Provide input from users of the Node database to aid in future development of this and other PDS Discipline Nodes: The PDS concept is designed to aid research activities; since this is a relatively new way of "doing business," PDS interaction with the user community is essential to determine if the lines along which the system is being developed are indeed providing useful research tools.

Description of the Atmospheres Node User-Interface and Data Analysis System

The user-interface and data analysis software package to access the Node's database is written in XIDL and runs on LASP's ORION VAX 11/785. The system provides a series of menu screens, allowing construction of Structured Query Language (SQL) queries that are passed to the Britton Lee Relational Database Management System (RDBMS) on which the database is resident. Retrieved data are first stored in a temporary table on the Britton Lee, then written out to a VAX data file. Subsequent menu screens allow selected data to be manipulated and plotted. Experienced users may also elect, at any time, to exit into interactive XIDL for non-menu-driven data manipulation. Files (both data and plots) can be copied to the user's host computer for further specialized data analysis or the production of hardcopy.

A typical session begins with viewing a list of the available datasets (tables), followed by selection of a table, viewing and selection of parameters (elements) to constrain, entry of desired constraints,

viewing and selection of elements to report (write to the VAX file), review of the SQL query as constructed in the preceding steps, entry of the VAX file name, and finally, execution of the query and retrieval of the constrained data. Following creation of the VAX file, the user loads elements into any of ten variables accessed by the data analysis system. These variables can then be manipulated (numerous arithmetic functions, Fourier transforms, binning, applying offsets, etc. are available) and plotted directly to the user's terminal screen. Another set of menus allows the appearance of a plot to be easily customized (labels, scaling, symbols, etc. are user-selectable). At this point, the plot can be sent to a laserprinter for publication-quality hardcopy, or saved as a file for future transfer to the user's host computer.

Workshop Summary

The first day of the workshop was spent familiarizing the participants with the hardware and software available for their use. The major topics covered during the introduction were: (1) a discussion of the structure of relational database systems, and features of the Britton Lee RDBMS; (2) a discussion of the workshop objectives, approach, and research scenarios; and (3) an overview of the Atmospheres Node User's Guide, which details the datasets stored on the Britton Lee, the structure of the query and data analysis system, and examples of the exact menu screens encountered (in the form of a logged sample session). Following this introduction, the user-interface and data analysis system was demonstrated by constructing sample queries, retrieving data from the RDBMS, and manipulating the resulting files to the point of producing customized graphs on a laserprinter. The participants then logged onto their own accounts (everyone was assigned space in a common workshop directory to avoid exceeding individual disk-space quotas) and spent the remainder of the day experimenting with the interface. Within a few hours, everyone was adept enough with the system to be producing useful queries, retrievals, plots, and analyses.

The second day began with another meeting to discuss the group's experiences with the system, to review the system's performance, and to develop a strategy to produce queries and perform data retrievals of mutual interest. Our goal was defined as examining correlations between cloud occurrence, water vapor abundance, and surface properties. It was agreed that we would concentrate on the generation of several files constrained within relatively narrow limits of latitude and season; each parameter would then be plotted against longitude to look for correlations. Individuals were assigned to generate one or more of the required files. The following parameters and constraints were chosen as the basis for the initial investigations:

Constraints:

latitude = 0 to 10 degrees
 L_s = 40 to 60 degrees (Viking mission year 2)
 hour = 10 to 14

Parameters:

IRTM cloud counts
 IRTM 15 micron temperatures (T_{15})
 IRTM T_{20}
 IRTM $T_9 - T_{20}$ (sensitive to dust clouds)
 IRTM $T_{11} - T_{20}$ (sensitive to water clouds)
 IRTM phase-corrected albedo (clouds)
 IRTM phase-corrected albedo (surface)
 MAWD water vapor abundance
 cloud locations (from the image-based cloud catalog)
 haze locations (from the image-based cloud catalog)
 surface elevation (from the MAWD dataset)

By the end of the day, the necessary files had been produced, and a variety of plots had been created. One plot in particular had been found surprising—the comparison of IRTM cloud albedos with IRTM

surface albedos suggested the clouds to be “darker” than had been expected. At this point, given the large quantity of data presented, one comment was that “it was all a bit overwhelming.” The next step, left for the following day, was to determine what other levels of processing would be meaningful from a research point of view and would aid in physical interpretation of the existing data.

The third and final day of the workshop again began with a discussion of the previous day’s activities and results. The consensus was to further examine the intriguing albedo correlation by retrieving data over a much larger area of Mars, attempting to both verify this correlation, and to determine whether it was an artifact of atmospheric dust, cloud type, etc. It was felt that other topics of initial interest, such as examining relationships between water vapor abundance, cloud occurrence, and topography, were good topics for follow-on work from the participants’ home institutions. While some of the participants went to work producing the expanded albedo datasets, others familiarized themselves with datasets, such as those from the Viking Lander Meteorology Experiment, which they had not previously had access to “on-line.” By mid-afternoon, everyone regrouped to take a final look at the numerous plots. The albedo data, this time covering the area extending from -20 to +40 degrees latitude, confirmed the observations made the previous day. It was agreed that further modelling and data analysis would be necessary to understand the significance of this finding. Before adjourning, we entered into a general discussion of the “workshop experience,” including participants’ impressions of the utility of the current database system and comments on possible future improvements in the system. These remarks, along with others gathered through the course of the workshop, are tabulated below.

General Comments Pertaining to PDS and the Atmospheres Node

1. The participants felt that continued remote access to the existing Atmospheres Node database, with the understanding that the interface and available datasets are prototypical and will be evolving with time, would provide a useful research tool to the community.

2. A workshop environment is a good means of introducing new users to the PDS databases and capabilities. The time participants spend with the developers of Node database and software systems facilitates their becoming adept at using these tools. Workshops also combine the expertise and focus of the various members of the group so that all participants can readily learn the contents and history of various datasets and discover the cautions needed to successfully integrate them. PDS-sponsored topical workshops should be organized by the various Discipline Nodes on an ongoing basis.

3. The process of reviewing and validating datasets is of major importance. As part of this activity, especially when dealing with derived datasets, details of the processing history, including caveats on use and references to publications using the dataset, are essential. Given the peer review expected to be an integral part of dataset submission to the PDS, dataset contributors should be able to reference accepted datasets as they would research publications.

4. Users and submitters of datasets should be consulted when defining the structure of the dataset as it is added to a Node’s database. This may help produce data structures that will optimize retrieval times for commonly executed queries.

5. Participants were interested in how active the Nodes will be in meeting the needs for applications software to deal with specific datasets. Will the Nodes require the submission of associated applications software along with datasets, and how will this software be overseen and made available to others?

6. Model results, such as those produced by Global Circulation Models, are valuable datasets. How will PDS provide for the use of such datasets?

7. Attention needs to be given to the correlative use of data stored online in relational databases (such as on the Britton Lee) and data residing on other storage media (both online such as VAX disk files, and offline such as on magnetic tape, CD-ROM, etc.). There will also be a need for correlative studies using data residing in different PDS Nodes and image facilities. How can such cross-component correlative activities be supported by the PDS?

Conclusions

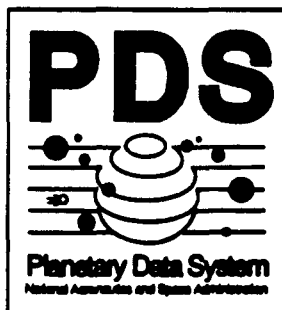
In general, this initial workshop was a success—useful datasets were available, and the participants were able to use them with reasonable facility and effectiveness. The ease of database access and

data analysis provided by the user-friendly, menu-driven interface was found to be particularly attractive. A number of research ideas surfaced during the workshop that will be pursued further by the participants from their home laboratories. Very constructive technological and operational feedback was obtained from the participants that will be useful in further design and refinement of the prototype planetary atmospheres Discipline Node. Perhaps most reassuring, the participants left with an enthusiasm for the research possibilities that should be available when the PDS becomes operational.

Prototype Atmospheres Node Data Access System User's Guide

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University of Colorado
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**Demonstrated At:
American Astronomical Society's
Division for Planetary Sciences Meeting
November 9 - 13, 1987
Pasadena, California**



This system has been developed as a part of or in conjunction with the Planetary Data System. The Planetary Data System is a project whose objective is to develop a cost effective mechanism for archiving planetary science data and allowing users easy access to this data and information about this data. The project is sponsored by NASA's Division for Solar System Exploration and NASA's Office of Information Systems. For more information on the Planetary Data System please contact Dr. Tom Renfrow, PDS Manager, at JPL, 4800 Oak Grove Drive, Pasadena, CA 91109 (818-354-6347).

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Chapter 1

Introduction

This manual describes the data access software being developed at the University of Colorado Laboratory for Atmospheric and Space Physics (LASP) as part of the PDS project. The primary purpose of this software is to enable scientists to easily access science data stored in a relational database and to use the data for on line analysis or store the data in a VAX file for later analysis or for transfer to the user's home computer. Although the software is being developed at the PDS prototype Atmospheres node, the system is not specific to the data at that node.

The data access software runs on a VAX 11/785 under VMS. It makes use of the data analysis and display capabilities of XIDL (the Interactive Data Language) and communicates with a Britton Lee IDM500 Relational Database Management System (RDBMS) on which the database itself resides. Queries to the Britton Lee are expressed in SQL (Structured Query Language, a standard language for querying relational databases). The relational nature of the database, combined with the capabilities of XIDL and the data access software, facilitates correlative studies of multiple data sets. Access to the system is provided via the Space Physics Analysis Network (SPAN), via dialup phone lines, or by visiting the Node.

The data access software is a menu-driven system, eliminating the need for users to become familiar with high-level languages for accessing and manipulating the database. The system provides a series of menus that prompt the user for construction of the queries used to constrain any data set resident on the RDBMS. Data records meeting the constraints applied by the query are written out to VAX data files. Subsequent menus allow the data to be manipulated (numerous arithmetic functions, such as Fourier transforms, binning, and applying offsets, are available) and plotted interactively by the user. The appearance of plots can be customized using the provided

menus. Plots can be displayed directly on the user's terminal, routed to a laser printer for publication-quality hardcopy, or saved as a file for future analysis. Files (both data and plots) can be copied via SPAN to the user's host computer for specialized analysis or hardcopy production.

Chapter 2

Becoming An Atmospheres Database User

To become a user of the Atmospheres Testbed database, send your request to Steve Lee (ORION::LEE on SPAN or by telephone 303 492-5348) or Sally Lasater (ORION::LASATER or telephone 303 492-6816). Please include the reasons that you would like to use the Atmospheres data including topics of special interest to you. This information helps us keep track of the directions it may be most fruitful to follow in developing this testbed node.

An account will be set up for you on the LASP ORION Vax and you will be notified when it is ready. Login to your account on ORION. This can be done using SPAN or by dialing in. Three dial in numbers are available. The numbers and their associated modem types are:

- 303 444-5046 — Vadic-1200
- 303 444-5048 — Bell-300, Bell-1200, Vadic-1200
- 303 444-5057 — Bell-300, Bell-1200, Vadic-1200

As part of the login processing for your account your default directory will be set to your subdirectory in the PDS workspace and the top level interface will be started. One of the options on the top level menu will be to start the interactive data access software. See Chapters 3 and 5 for detailed information on this system.

Your personal disk quota will be fairly limited. However the directory called [PDS.WORKSHOP] to which you will have access rights has a larger quota. Files created using the data access software will be created in that directory

and the quota will be charged to that directory. As all PDS Atmospheres users will be using this directory as a workspace (each in a subdirectory identified by the user name) it is important that you always delete your files when you have finished with them.

Send your comments and suggestions to Steve Lee or Sally Lasater.

Chapter 3

The Data Access Software

3.1 Purpose

The data access software under development at LASP presents a menu interface to the combined capabilities of XIDL and the Britton Lee database machine, providing scientists a means of retrieving data from the Britton Lee and using the data for on line analysis. Data retrieved are stored in VAX files and can be copied to home institutions for further analysis. In addition, analysis results in the form of plots can be stored in VAX files and transferred to other computers for printing or display. See Chapter 4.

XIDL is a software system for the analysis of scientific data, a programming language, and a plotting and image display package. The Britton Lee database machine is a relational database management system. The machine at LASP contains the testbed Atmospheres database — planetary atmospheric data that is being collected as part of the PDS project. The data access software is not restricted to use with this data however.

The data access software is written primarily in XIDL with some FORTRAN 77. Queries to the Britton Lee are expressed in SQL. Data retrieved from the Britton Lee are stored in text files on the VAX. The software has run on GRAPHON and TEKTRONIX 4025 terminals and on MACINTOSH computers using the VersaTerm PRO software.

3.2 Getting Into The Data Access Software

When remote PDS users log onto the ORION VAX they are automatically presented with a top level menu of capabilities available to them at this

testbed node. Two of the options are related to the data access software. One is a tutorial that illustrates the basic capabilities of the software, the other puts the user into the interactive version of the software.

3.3 Capabilities

The options that you see on the top level menu for the data access software are described below.

3.3.1 Retrieve Data From Britton Lee

Selecting this option brings you into a set of submenus that allow you to identify data you would like to retrieve from the Britton Lee and issue a request for it.

Identifying the data that you are interested in includes:

- identifying the table or view containing the data that you want. You will select the table from a menu of tables and views that are currently available in the database. You must always specify a table as the first step in identifying the data of interest. Once you have selected a table that table will remain selected until you choose to change tables.
- specifying the criteria to be used to select records from the table. Specifying the criteria involves identifying the fields (parameters) on which you want to constrain from a menu of fields in the selected table and identifying the type of constraint to apply to each field. Constraints that can be applied include
 - Between — the value of a field must be between a specified maximum and minimum.
 - Not Between – the value of a field must be outside a specified range.
 - Equal — the value of a field must be equal to a specified constant.
 - Not Equal — the value of a field must not be equal to a specified
 - Greater Than, Greater Than or Equal, Less Than, Less Than or Equal — the value of the field must have the specified relationship to a specified constant.

Constraints can be added or deleted until you have assembled the desired set.

- selecting the particular data fields that you want returned from the records that matched the specified selection criteria. If you do not select particular data fields to be reported then all fields in the selected records will be reported.

Identifying data as described above is done by means of menus and prompts. The data dictionary that is part of this document describes the tables that are currently in the database and the fields that compose each table. In a future release this information will be on line and available to you from within the program.

After you are satisfied with your request (the program will show you the SQL version of the query you have specified if you wish) you execute the request. At this point you have two choices.

- You can request a count of the records that meet the constraints. You should select this option if you are uncertain whether you have adequately constrained the data. If the count of records that meet the criteria is larger than desired, you can return and modify the constraints to create a more satisfactory query. If the count is satisfactory, you can then select the other option — to actually retrieve the data.
- You can request that the data meeting the criteria be retrieved to a VAX file. You will be prompted for the name of the file in which the results are to be stored. They will be stored in *filename.DAT* in your default directory. In addition a file named *filename.HDR* will be generated that describes the contents of the data file. This header file will be in the PDS Label format when that is finalized. It will identify the
 - the table or view that was the source of the data.
 - the fields in the file. (Their type and format will be included in a future version.)
 - the number of records in the file.
 - the query used to select this data.

The execution of either of these options involves a delay while the query is executed on the Britton Lee. In most cases getting the count should execute more quickly than the retrieval as in the latter case the selected records are

written to a temporary table on the Britton Lee. Note that the length of time required to identify selected records depends on a number of factors such as the size of the table, the number and size of the records returned in answer to the query, the complexity of the query, and whether or not the fields used for constraining were indexed.

The actual retrieval of the data involves a second delay while the selected records are copied from the temporary Britton Lee table to the VAX file. This portion of the query can be affected significantly by the current user load on ORION.

Data from any of the files generated by this process can be read into variables global to this software. These in turn can be used for plotting or for any of the data massge operations. These features are described below.

3.3.2 Load Data Into Variables

After data has been selected from the Atmospheres database into a VAX file using the retrieve function described above, the user can load fields from the data file into vector variables global to this program. The loaded variables can then be used for plotting or for input into data manipulation functions.

When this option is selected the user is prompted for directory and filename of the file containing the data to be loaded — [LEE]VL2AVG for example. This will be the same as the name you assigned to the output file when you retrieved the data. (An option to show the directory contents will be added to the software during the next development phase.)

The program then reads the *filename.HDR* file described above and displays the names of the data fields in the file. You identify each field whose values you want stored in a variable and the variable in which you want it stored. The data for all identified fields are then read into the identified variables.

Data from more than one file can be loaded into the variables by repeating the load function for each file. There are currently ten variables allotted for this purpose.

3.3.3 Show Variable Contents

This option displays the current contents of the global variables P0 thru P9. If the variable contains data read from a file, the procedure displays the name of the field and the file from which it was read. If the variable contains the

results of a data manipulation function, the procedure displays the equation that was used to derive the variable.

The minimum and maximum value in the vector and the width of the vector are also displayed.

For example:

```
0 P0 MARTIAN_DAY Table: MARS_VL_AVEP File: VL2AVG
   Min = 0.0   Max = 1050.0   Size = 970
```

```
3 P3 P0 - 10
   Min = -10.0   Max = 1040.0   Size = 970
```

The above shows that variable P0 contains MARTIAN_DAY data from the table MARS_VL_AVEP from the file VL2AVG in the default directory. The values of MARTIAN_DAY range from 0 to 1050. The vector contains 970 values. Variable P3 contains the result of subtracting 10 from each element of P0.

3.3.4 Plot Data

This option gives you access to the IDL plotting routines. After selecting a plotting type (the only available option at the moment is XY plotting), you will be prompted for the variables to be used in plotting and a plot will be displayed to your screen. The plotting parameters such as the axis titles, the axis minimum and maximums, and the plot symbol will be the default values assigned by the system. When you have completed viewing the plot, entering carriage return will clear the screen and a menu of options for tailoring your plot will appear. Tailoring options include:

- Adding an axis to the plot. If you select this option you will choose the type of axis you wish to add from a menu of axis types. After selecting the type you will be prompted for the other information needed to define the axis such as the title and the axis minimum and maximum.
- Displaying the plot again. After making an adjustment you may wish to look at the plot again to verify your change had the anticipated result.
- Storing the plot in a file. If you produce a plot you like, you can store the plot in a file so that you can copy it to a home institution or save it

for later use. You will be prompted for the name of the file in which to store the plot and you will select the type of plot file to be generated from a menu including the following choices:

- NCAR metacode file.
 - Tektronix/Regis compatible file.
 - QMS laser printer file.
 - Postscript laser printer file.
- Adding an overplot. You may add up to four overplots to the first plot. Overplots will be plotted against new axes if you have added any axes. You will identify the new plot variables from a menu of the current variables.
 - Modifying plot parameters. When you select this option you will be shown a menu of plotting parameters that can be changed. After identifying the parameter you wish to change you will be prompted for the new value or shown a menu of values from which to choose, depending on the parameter.
 - Sending the plot to a LASP printer. If you are working at LASP, you can route the plot directly to one of the LASP printers.
 - Showing the current variable contents. If you are considering adding an overplot and want to review the current contents of your variables choose this option.

3.3.5 Message Data

This option gives you access to various functions such as math functions, vector concatenation, and binning. After selecting a function you will be prompted for the global variables to be used as input for the given function and for the variable in which to store the result. The results of all functions except for the binning functions are stored in one of the global variables P0 - P9. The results of the binning operation are stored in the variables BIN_AVERAGES, BIN_COUNTS, BIN_MINIMUM, and BIN_RANGE.

The variables to be used as parameters must have been loaded with data before calling this function. The current contents, if any, of a variable used to store the result of an operation will be overwritten by the result. A variable can be used as both an input parameter and the result parameter as in $P0 = P0 + 6$.

Note that in operations between vectors and constants the operation with the constant is applied to each vector element. In operations between vectors ($P0 = P1 * P2$ for example), the operations are applied between corresponding elements of the two vectors. If the vectors are different sizes the result vector is the length of the shorter vector. For any further details on the manipulation functions consult the XIDL manual.

3.3.6 Help

If you select HELP you will be prompted for the menu item on which you want help and the associated information will be printed to the screen.

3.3.7 Z

If you know XIDL it is very likely that you will want to exit this interface program from time to time and do things directly in XIDL. Selecting Z returns you to interactive XIDL. You may reenter the interface again by typing MAIN_MENU in response to the IDL prompt. All values should be the same as when you left the program unless you have modified them in interactive XIDL which is strongly discouraged.

Accessing the Atmospheres Database

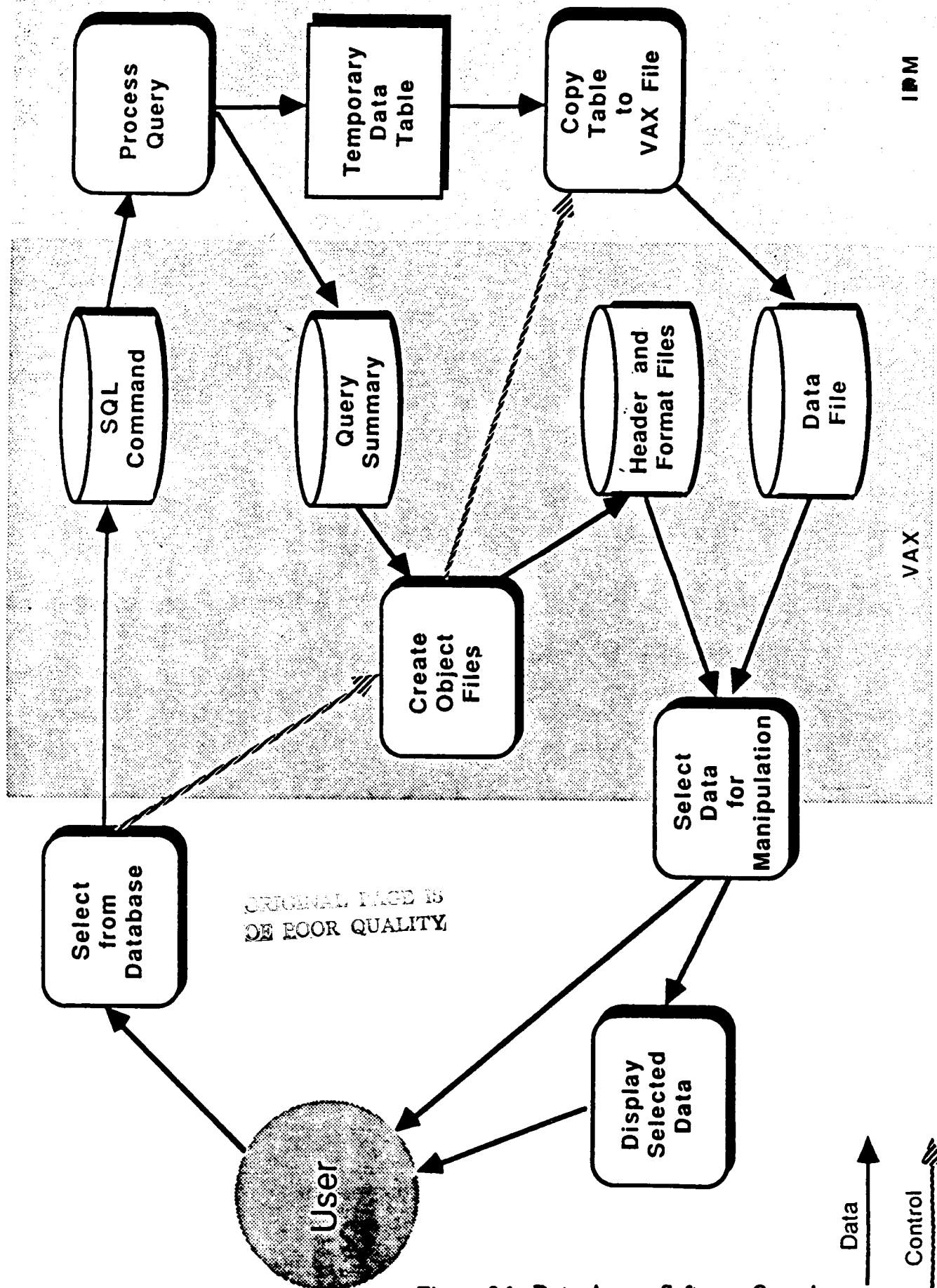


Figure 3.1: Data Access Software Overview

Chapter 4

Sample Plots Using Atmospheres Data

The following pages contain some sample plots generated from data in the Atmospheres database using the data access software available at the prototype Atmospheres Node.

The first plot illustrates a plot from a single table as it would appear before tailoring the plot by adjusting plotting parameters. The data are from the MARS_TOPO table for elevations between 0 and 1 kilometer.

The second plot is identical to the first but the plotting parameters have been modified to tailor the plot's appearance.

The third plot illustrates an overplot, with two types of data plotted together. The data are from the MARS_VL_AVEP table.

The fourth plot illustrates combining information from more than one data set on a single plot. The data are from the MARS_TOPO table and the MARS_TH_INER table.

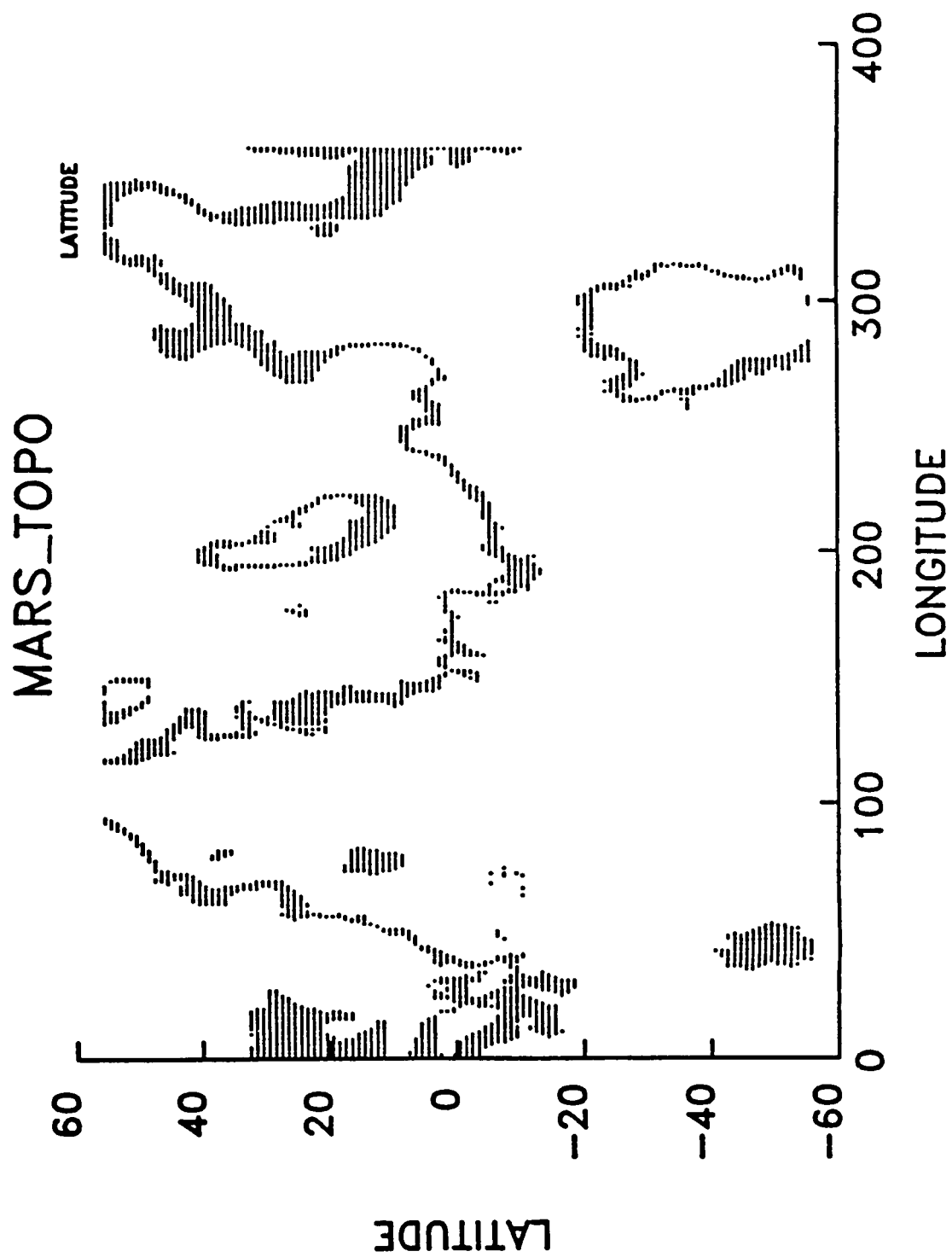


Figure 4.1: Raw Plot

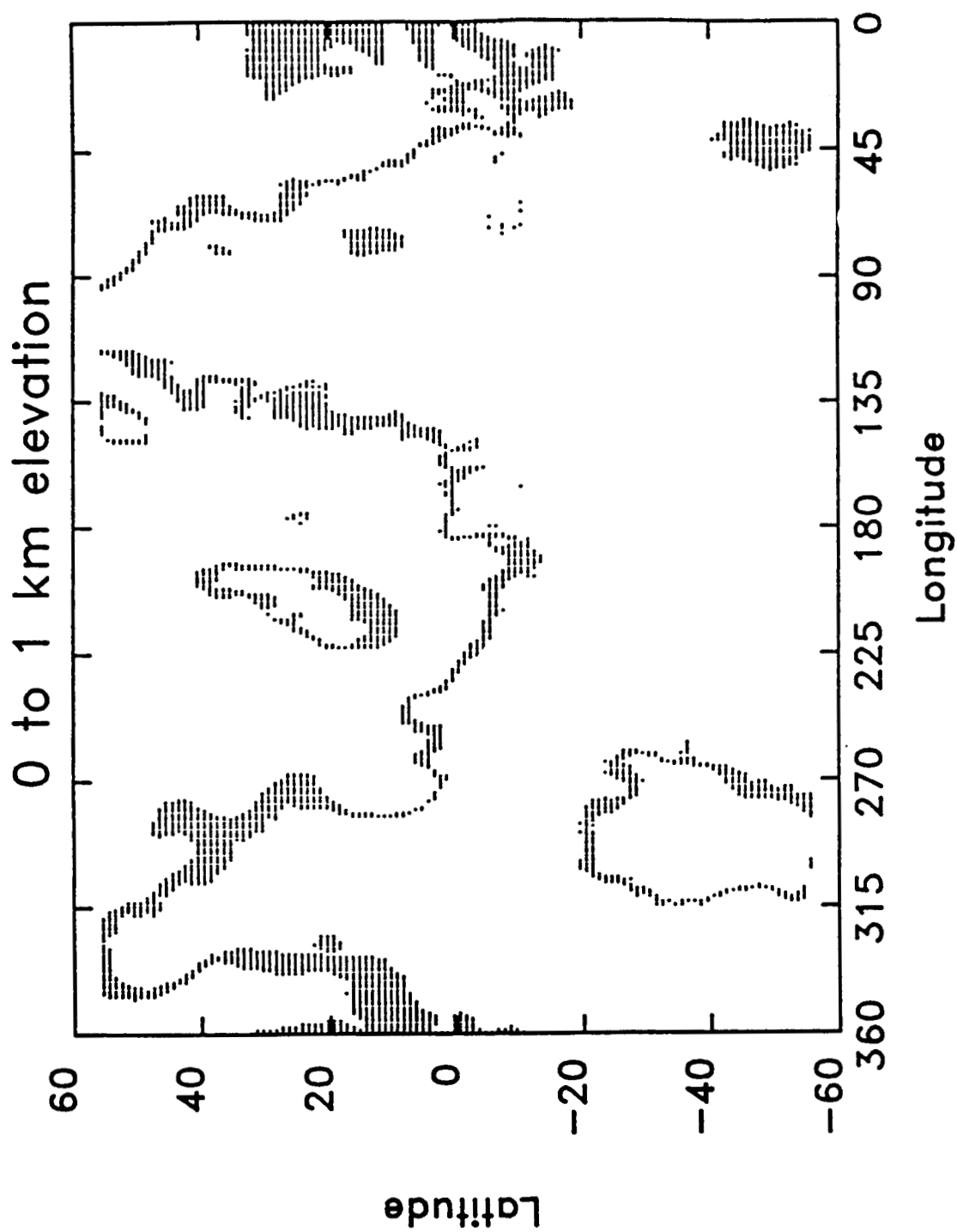


Figure 4.2: Tailored Plot

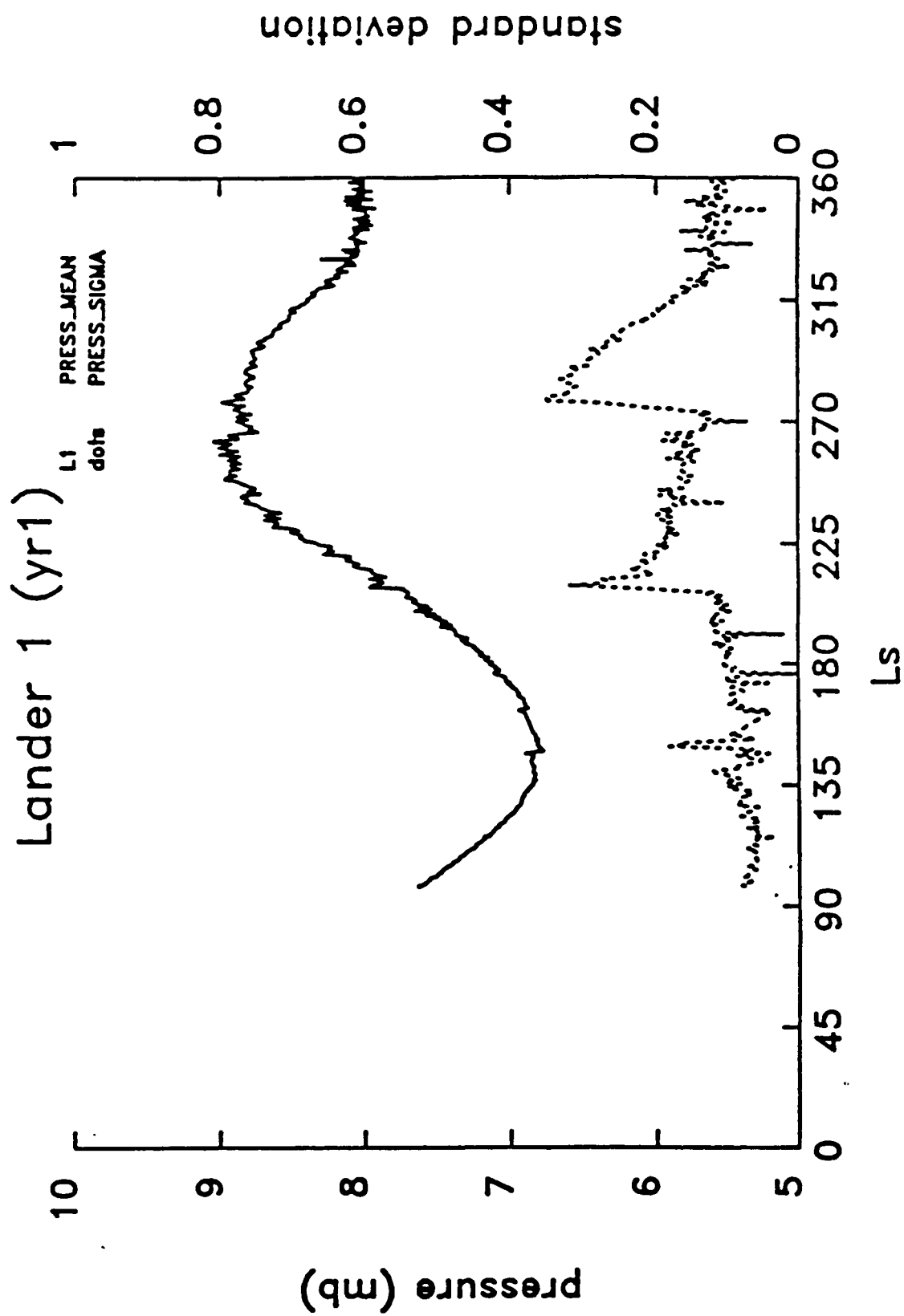


Figure 4.3: Plot With Overplot

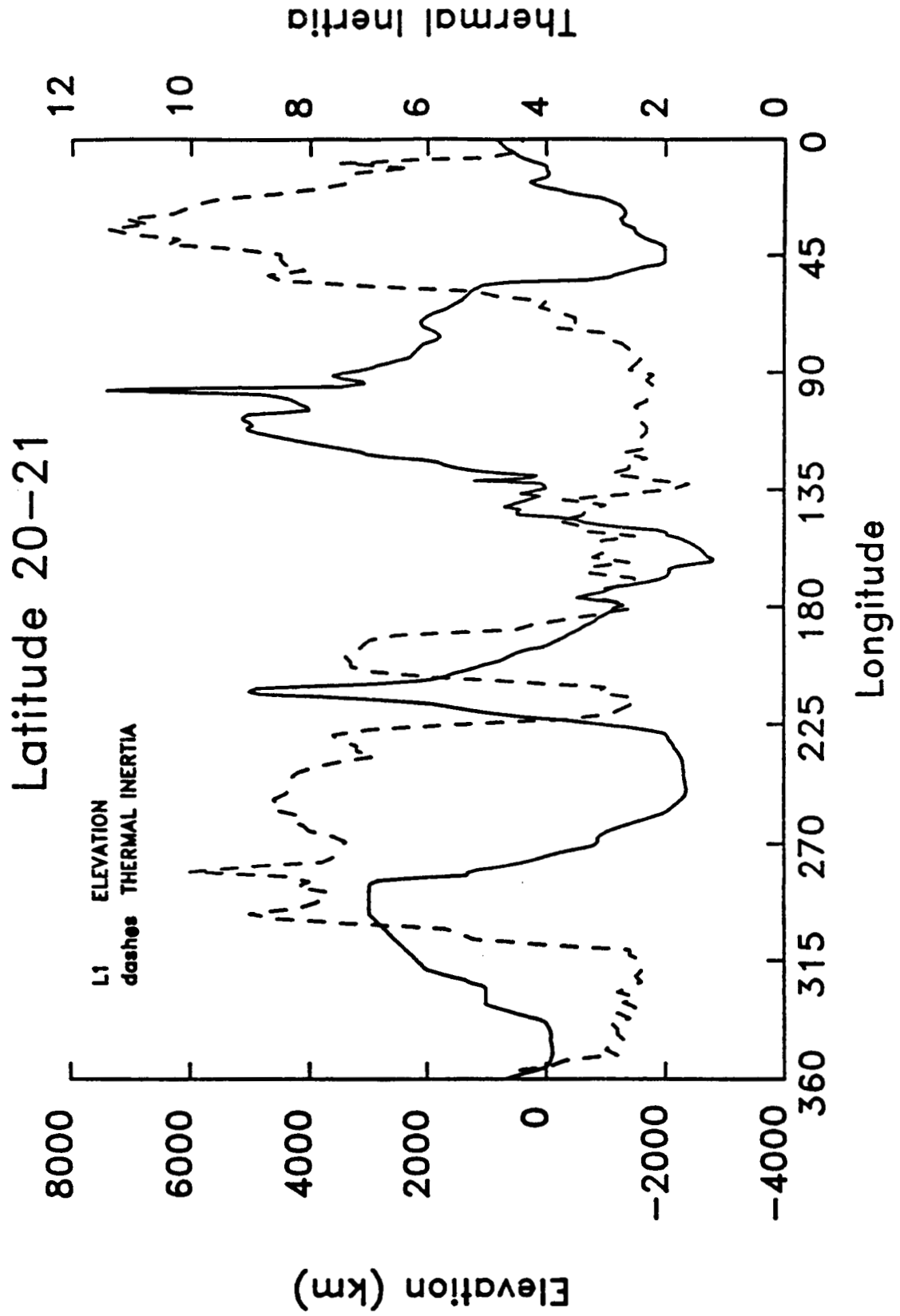


Figure 4.4: Plot Using Two Data Sets

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